Lake Anna Fisheries Management Report

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Lake Anna is a 9,600-acre impoundment owned by the Dominion Virginia Power Company. The lake spans Louisa, Spotsylvania and Orange counties and serves as cooling water for the two-unit North Anna Nuclear Power Station. Fish stocking began in 1972 with introductions of largemouth bass, bluegill, redear sunfish and channel catfish. Subsequent stockings of redear, channel catfish, walleye, striped bass and largemouth bass (both Florida and northern strains) were made. Threadfin shad and blueback herring were successfully introduced in the 1980s. Striped bass and walleye have generally been stocked annually. A 12-15 inch slot length limit was established to restructure the largemouth bass population in 1985. Prior to that time, a 12-inch minimum size limit was in effect. A 20-inch minimum length limit regulates striped bass harvest.

A 2000-2001 daytime creel survey (a survey where anglers are interviewed about their fishing habits, preferences and success rates) indicated that annual fishing pressure was 24 hours/acre. This rate was below the previous Lake Anna sample (30 hours/acre in 1992); however, the 1992 survey was conducted only during warmer months and likely was an overestimate when expanded for the entire year. Fishing pressure at Lake Anna was among the lowest of large Virginia reservoirs and was similar to Kerr Reservoir (23 hours/acre).

Preferred species selected by anglers in 2000 included largemouth bass (69%), striped bass (15%), crappie (12%) and catfish (2%). These fishing preferences were remarkably similar to those documented nearly ten years earlier (for example, 72% selected largemouth bass and 14% selected striped bass in 1992). Dominant species *caught* (by number) were black crappie (56,308 or 53%) and largemouth bass (38,245 or 36%), but most largemouth bass were released. Thus, dominant species *harvested* (by number) were crappie (39,167 or 84%), channel catfish (2134 or 5%), and white perch (2,111 or 5%). Striped bass comprised only 4% of the total number of fish harvested but accounted for 30% of the biomass. Lake Anna and Smith Mountain Lake had similar, moderate (below average) largemouth bass catch and harvest rates, while Lake Anna crappie and catfish creel statistics were above average and similar to those at Kerr Reservoir. Dominant species harvested (by weight) were crappie (16,272 pounds or 49%) and striped bass (10,114 pounds or 30%). Compared to other Virginia reservoirs, anglers at Lake Anna harvested low numbers of largemouth bass but high numbers of crappie, catfish and striped bass. Average weights of fish harvested in 2000 at Lake Anna were 3.0 pounds for largemouth bass, 0.4 pound for black crappie, 5.9 pounds for striped bass and 1.8 pounds for channel catfish. Largemouth bass anglers released 99% of all bass caught at Lake Anna (only 502 were harvested during 12 months for a total weight of 1512 pounds). This release rate was even higher than the 97% largemouth bass release rate documented in 1992 and demonstrated the extent of the catch-and-release ethic.

The aquatic weed Hydrilla verticillata became established in Lake Anna during the late 1980s, and abundance increased rapidly--from 96 acres in 1990 to 832 acres in 1994. Sterile (triploid) grass carp (N=6185) were stocked into Virginia Power's Waste Heat Treatment Facility (WHTF) in 1994 to control Hydrilla. The WHTF is separated from Lake Anna by three dikes, and thermal effluent enters the lake via gravity flow under the third dike. All grass carp stocked in the WHTF were marked with coded wire micro tags. No grass carp were stocked in Lake Anna.

Historically, rotenone sampling at Lake Anna was conducted every three years to generate species composition and biomass estimates. This sampling involved the poisoning of four coves with a piscicide, and collected data were used to evaluate forage abundance (gizzard shad, threadfin shad, and blueback herring) for stocked predators and monitor overall fish community composition. However, due to extremely high variances in biomass estimates, heavy shoreline development (with the potential for public relations problems) and intensive manpower requirements; rotenone use at Lake Anna was discontinued after 1995. Increased gill netting with larger, multi-panel nets was determined to be an adequate replacement for community structure and forage evaluation while providing the needed data for predator stocking evaluation. Current annual sampling protocols include spring electrofishing for largemouth bass in the upper, middle and lower portion of the reservoir. Upper lake electrofishing is conducted above "the splits" on both major tributary arms; middle lake sampling is conducted below the splits to the vicinity of the Route 208 Bridge; and lower lake sampling is conducted between the Dam and Dike II. Gill net surveys are stratified by upper and lower lake (using Route 208 as the boundary), and specific sites are selected based on a random block design. A total of 36 net nights of effort are conducted annually (one net set overnight is one net night). Gill nets are 200 X 8 feet and have eight different 25-foot panels that allow the sampling of most sizes of fish present in the lake. Typically, with either gear; fish are measured for total length and weight and released. However, ear stones (otoliths) may occasionally be removed from fish to determine exact age. This information is crucial when evaluating certain population parameters and determining stocking success.

Stockings during the past decade included striped bass and walleye (Table 1). Stocking rates and locations were variable in attempts to maximize hatchery resources. Stocking evaluations are included below as part of a species-by-species summary of fish population status.

Largemouth Bass

Largemouth bass mean electrofishing catch rates (CPUE, or number caught per hour of electrofishing) for all size groups increased or remained stable over the past decade and were at or near record levels as recently as 2001 (Table 2). Size groups of largemouth bass are universally defined as stock (at least 8 inches), quality (at least 12 inches), preferred (at least 15 inches), and memorable (at least 20 inches). CPUE of fingerling and stock-size bass remained remarkably stable between 1993 and 2002. Stock-size fish are generally considered to be mature (or nearly so) and recruited to the population. Minimal variation in bass fingerling catch rate suggested Lake Anna is a stable system and produces consistent year classes (or cohorts) of bass from year-to-year. Minimal variability in stock-size bass catch rate similarly suggested the adult population was stable. The slight variation in stock bass catch over time (actual data points rather than the trend line) was likely due to sampling variability (Figure 1).

Catch rates of larger bass (e.g., quality and preferred-size) increased during the past decade and reached records in 2001 before declining in 2002 (Figure 2). However, it is believed that 2002 data were biased by the severe drought that affected the region during the latter half of 2001 and most of 2002. Lake Anna was never below full pool during spring electrofishing surveys until 2002 when it was down two feet. Total CPUE (fingerling + stock) remained nearly static over the period and averaged 60 bass/hour. These data are commensurate with other large Virginia reservoirs. Total CPUE was always significantly higher in the middle and upper lake portions than down lake. This was likely due to the noticeable productivity gradient, expected in a tributary storage impoundment, that supports higher biomass at upstream locations.

Largemouth bass structural indices (PSD and RSDs) paralleled catch rates and further suggested that population structure shifted upwards (towards larger individuals) recently (Table 3). PSD (proportional stock density) is an index that describes the size structure of a population and may be used in context of predator/prey relationships to determine balance within a fish community. Simply, the larger the number; the larger the proportion of big fish in a population. PSD for largemouth bass is determined by the ratio of the number of bass that are greater than eight inches but also greater than 12 inches. Similarly, RSD-P (relative stock density of preferred bass) is a ratio of the number of bass that are greater than eight inches but also greater than 15 inches. PSD and RSD-P were at or near record levels in 2000 and 2001 but declined to 65 and 29 in 2002. These levels were slightly below average but not believed to be indicative of a real shift in population size structure. PSD values between 40 and 60 are generally considered to represent balanced bass populations.

Otoliths from a subset of bass collected during electrofishing were removed annually during the last several years to evaluate growth and mortality. Bass growth rates were above average for young fish, as fish reached 7.2 inches, 10.6 inches and 13.1 inches by their first, second and third years (Figure 3). However, growth slowed in the upper portion of, and just over, the slot. A typical bass grew out of the slot at 4.4 years and averaged only about one inch per year until age eight or nine. Evidence suggested that bass at Lake Anna may be stockpiling and stunting, albeit at a more desirable size than typically occurs. Current growth patterns require a bass about ten years (at a conservative minimum) to reach citation length (22 inches). Based on growth curves, it's more likely that citation bass are at least 12 years old unless other factors are at work (e.g., cohort interactions, forage and growth variability). Fish up to age 13 were collected during recent investigations.

Total annual mortality (the percentage of the bass population that dies each year from all causes) was 27% for fish aged 2-12 based on a catch curve of bass sampled in 2002. When other years were combined, the overall mortality estimate was 31%. While these estimates assume constant recruitment (equal production of young fish from year-to-year), they are low and support current and previous findings at Lake Anna (e.g., high bass abundance and structural indices, rapid to slow growth pattern, low relative weight, and low harvest). Total annual mortality is composed of natural and fishing mortality. Estimates of annual natural mortality were similar to the rates listed above (for total mortality) and suggested fishing mortality was very low.

Relative Weights (Wr, a measure to describe the plumpness or well-being of a fish) were highest in upper lake bass and declined down lake. The lowest Wr values were from lower lake fish. Overall, Wr values at Lake Anna were lower than for largemouth bass from other district waters.

Stomachs taken from fish sacrificed for otoliths were analyzed, and 61% were empty. Bass that had stomach contents ate fish (35%), artificial lures (2%), crayfish (1%) and insects (1%). Many consumed fish were unidentifiable, but the following were observed in decreasing abundance: bluegill, white perch and threadfin shad. It is likely that many of the unidentifiable items were shad (either gizzard or threadfin).

Striped Bass

Striped bass were stocked annually at a variable rate (Table 1) in an effort to determine an optimum stocking rate for Lake Anna, as overstocking could result in reduced growth, survival and/or recruitment. Lake Anna striped bass stockings were evaluated with gill nets, and it was assumed that nets gave unbiased population samples of fish under age 5. Older (larger) individuals were caught periodically and provided useful information, but the maximum bar mesh size of 2 inches precluded reliable sampling of larger striped bass.

Generally, young fish grew quickly through age 3 (when they reached the legal 20-inch minimum size), but growth slowed thereafter (Figure 4). Striped bass averaged 10, 18 and 22 inches at ages 1, 3, and 5. Ages were rounded up, as fish were collected during winter before completing a 12-month growing cycle; however the growing season of the ensuing age had been completed. This pattern of striped bass growth (rapid growth of juvenile and sub-adult fish followed by slow growth of adults) is common in southeastern reservoirs with marginal habitat such as Lake Anna. Habitat needs shift as striped bass age, and summer conditions at Lake Anna typically find water temperature and dissolved oxygen combinations marginal for adult striped bass, especially in the lower portion of the reservoir. For comparison, striped bass at Smith Mountain Lake; a reservoir with good adult striped bass summer habitat, averaged 10, 21 and 26 inches at the ages 1, 3, and 5.

Several variables were evaluated to determine if relationships existed between stocking size and rate and size or abundance of fish following stocking. No significant relationship existed between stocking size and total length of age 0 fish, total length of age 0 fish and catch rate of age 0 fish, or number stocked and catch rate of age 0 fish. These findings suggest that the number of striped bass that recruit to the population is based, at least in part, on other variables (perhaps environmental effects or forage abundance). However, only six years of data were available for evaluation, and it is possible that relationships may become apparent as the data set is enhanced. It was noteworthy that catch of age 0 fish was lowest with the lowest stocking rate (5 per acre) but highest with intermediate stocking rates (10-11 per acre). Stocking rates of 20 or more per acre resulted in intermediate catch of young striped bass. The catch of age 1 fish may be a better indicator of year class strength or stocking "success", but additional data are required for analysis.

Cohort based mortality estimates were calculated for each striped bass year class with ample data (1997-2000). These estimates provided the total annual mortality rate – that is, the percentage of the year class that died each year from all causes. Essentially, each stocking was considered a subgroup, and these groups were followed through time to see how they survived. The oldest year classes had the most data points (or years of catch-per-unit-effort data) and provide the best (or most significant) relationship. The 1997 year class had only a 28% total annual mortality rate (fish age 0-5) which translated into a high 72% survival rate. Two other survival estimates, while not as significant, were similar and ranged from 75-80%. Only one estimate had lower survival, but it was the year class with the fewest data points. These findings suggest that the overall mortality rate for striped bass at Lake Anna is low.

Relative abundance of striped bass in Lake Anna was estimated by catch rate or catch per unit effort (CPUE). This was simply the number of striped bass caught per net night of effort. Since new netting protocols were established in 1997, CPUE for striped bass in gill nets has ranged from 3.0 (1998) to 4.8 (2000). CPUE in 2002 (3.7) was equivalent to the six-year average. Most striped bass were caught in the upper portion of the reservoir. The North Anna River from Rose Valley upstream to Route 719 and the Pamunky River from Jetts Island upstream to Terry's Run were typically very productive locations during November netting.

Walleye

Walleye were historically stocked sporadically at Lake Anna (Table 1). However, as a result of a statewide walleye study and recommendations by the DGIF Walleye Committee, stockings were stabilized after 1997 with at least 25 per acre stocked thereafter (Lake Anna was included in a statewide walleye research project, and a special addition of *Virginia Wildlife* Magazine was published in June 2001 detailing findings. Reprints are available from DGIF Regional Offices). In addition to increasing the stocking rate and frequency, new stocking sites and methods were added in an effort to spatially expand the population after it was discovered that most walleye were confined to the Pamuky River tributary arm. It was hypothesized that since all historical stockings had occurred in this arm of the upper reservoir, the population was exhibiting a homing tendency thereby limiting dispersion. Walleye stockings were evaluated with gill nets, and it was assumed that nets gave unbiased population samples of fish under age 4. Older (larger) individuals were caught periodically and provided useful information, but the maximum bar mesh size of 2 inches precluded reliable sampling of larger walleye.

Like striped bass, young walleye grew rapidly at Lake Anna attaining 19 inches after only three growing seasons (Figure 5). However, after reaching about 20 inches, growth declined and became sporadic. Further increases in total length occurred very slowly. Walleye averaged 11, 19 and 20 inches at ages 1, 3, and 5. Ages were rounded up, as fish were collected during winter before completing a 12-month growing cycle; however the growing season of the ensuing age had been completed. Walleye up to age 12 were collected, but sample sizes were low for fish older than age 3. Walleye growth at Lake Anna was better than in District small impoundments (e.g., Lakes Orange, Brittle and Burke).

Efforts to spatially expand the walleye population by adding stocking sites in the lower, middle and upper portions of the reservoir initially seemed successful but now appear dubious. Beginning in 1999 with Duke's Creek, one or more annual stocking sites were selected in portions of the reservoir where walleye stockings had not historically occurred (new sites were Christopher Run, Sturgeon Creek and the State Park). The percentage of walleye captured with gill nets in the upper vs. lower portion of Lake Anna should be a reasonable indicator of population dispersion (the assumption being given equal effort, catch in lower and upper reservoir portions should be similar). Historically, walleye catch in the upper lake was at or near 100% but dropped to around 50% in 1999 and 2000 after lower lake stockings. This indicated lower lake stockings were spatially expanding the population; however, lower lake catch was mostly age 0 (young-of-year) fish. Recent years (including 2002 when catch rate was at a record level) saw upper lake catch return to the 80-95% range. Thus, the upper lake (specifically the Pamunky River arm) appears to possess habitat preferred by Lake Anna walleye.

The catch rate (CPUE) of walleye in gill nets ranged from 0.4 (fish per net night) in 1998 to 2.6 in 2002. Before 2002, the previous high was 1.6 (2000). Although no trend was apparent, the record catch in 2002 suggested new stocking protocols were finally increasing population size.

Black Crappie

Black crappie were evaluated with experimental gill nets in 1997-2002. It was assumed that gill nets sampled to the entire population without bias. Otoliths were removed from all fish captured in 2002 to develop estimates of growth and mortality. Crappie were typically the most abundant fish in gill nets, and although gill net effort was equal; most crappie (94%) were caught in the upper lake. Mean CPUE (catch per unit effort) in gill nets averaged 11.0 fish per net night between 1997-2002 with 1997 producing the highest (15.0) and 2000 the lowest (5.5) CPUE. CPUE in 2002 was above average after two years of below average catch.

Black crappie size structure was good in 2002. Average size was about 8 inches, but strong representation of 12-inch and over fish was present along with ample juvenile production. Crappie growth was moderate but highly variable (Figure 6). For example, age 3 fish averaged 8.3 inches total length but ranged from 5.8-12.4 inches. The mean length of age 3 crappie in other District waters (four small impoundments) was 8.5 inches in 2002. Sample sizes of crappie older than age 5 were small, thus the latter half of the growth curve (Figure 6) was biased. Fish up to age 13 were collected in 2002, and an age 16 crappie was sampled several years ago. This fish was a nine-inch male; further illustrating the highly variable growth of Lake Anna crappie.

Catfish

Catfish populations were evaluated with experimental gill nets in 1997-2002. The five species caught (in decreasing abundance) were channel catfish, white catfish, yellow bullhead, brown bullhead and blue catfish; however, only the former two contributed significantly to overall biomass. Channel catfish were usually the fourth or fifth most prevalent species taken in gill nets. Channel and white catfish CPUE (catch per unit effort) fluctuated during the period with no apparent trend within or between species. Highest CPUE occurred in 1998 for both channel (5.7 fish per net night) and white catfish (4.5 per net night), but lowest CPUE occurred in 1997 for channel catfish (2.3 per net night) and in 2002 for white catfish (1.5 per net night). Catch of channel catfish was above average in 2002, while catch of white catfish was below average.

Channel catfish was one of the few species sampled in nearly equivalent numbers in the upper and lower portions of the reservoir - over 40% were collected from the lower reservoir, but average size was significantly greater in the upper reservoir. White catfish lengths were identical from both portions of the lake, but only 28% were collected below Route 208. Average total length of channel catfish was 15 inches, but several large specimens were observed including a potential world record. This monster was caught in a gill net and released in good condition near Dike III in December 2002 after weighing in at over 55 pounds.

Two small blue catfish were caught (one in 1997 and 1998). Their origin is unknown, as no stocking records exist for this species in Lake Anna; however, blue catfish were stocked in the Lake Anna watershed (Lake Orange) during the 1980s.

Forage

The forage base (members of the shad and herring family or clupeidae) includes gizzard and threadfin shad and blueback herring at Lake Anna. Most of the forage biomass is composed of gizzard shad, although blueback herring have been a challenge to effectively assess, and threadfin shad abundance is cyclic – based largely on minimum water temperatures, as this species has the proclivity to "winter kill".

Estimates of gizzard shad biomass from historical rotenone samples ranged from near 100 to over 300 lbs/acre, while gill net CPUE (catch per unit effort) varied from 6.2 to 27.1 and averaged 14.0 fish per net night. The highest CPUE was in 2000, and the lowest was in 2002. It is unknown to what extent drought conditions in 2002 affected either the gizzard shad population or sampling efficiency, but reservoir levels were reduced in late 2001 when CPUE was 21.0. It is possible that even with increased effort (the current level of 36 net nights), sampling variability was still too high to effectively estimate true shad abundance. Further analysis will be necessary, and 2003 net samples may yield further insight into the low catch rate of gizzard shad in 2002.

Gill nets were compared to night electrofishing for forage assessment in 2000 and were found to give acceptable (unbiased) estimates of size structure and had lower associated sampling variability. The size structure of the gizzard shad population fluctuated frequently but usually had a bimodal length distribution. Size distribution was good in 2002 with three peaks indicating a good diversity of forage and an average size of 8.9 inches. Most shad (87%) were caught in the upper lake.

Other Species

Lake Anna is home to many other species – some of various recreational importance including redear sunfish and white perch and others important ecologically such as creek chubsucker and white sucker. Habitats are variable throughout the lake, and species abundance can be sporadic. For example, chain pickerel (a native top level predator and sport fish) prefer slow moving coastal plain systems where tannins from leaf litter frequently stain the water and reduce pH to a level lower than typically found in the piedmont. Contrary Creek, while suffering from acid mine drainage, offers a unique habitat in Lake Anna and supports a thriving chain pickerel population. These species are sampled periodically in gill nets, and their abundance can be gauged by catch per unit effort or number caught per net night (Table 4).

Table 1. Fish Stocking in Lake Anna 1993-2002 (numbers rounded to the nearest thousand; STB = striped bass, WAE = walleye).

	1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
STB	172	146	132	148	96	196	98	108	48	199
/ac	18	15	14	15	10	20	10	11	5	21
WAE	0	53	58	97	0	480	240	259	240	243
/ac		6	6	10		50	25	27	25	25

Table 2. Mean electrofishing catch per unit effort (CPUE) of various size groups of largemouth bass at Lake Anna, 1993-2002 (fingerlings are less than eight inches, stock are at least 8 inches, quality are at least 12 inches, preferred are at least 15 inches, and memorable are as least 20 inches); note no sample conducted in 1994.

	1993	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**Mean**
fingerling	13	4	7	5	8	8	7	7	10	**8**
stock	54	55	45	54	59	50	49	60	49	**53**
quality	31	36	28	41	42	37	39	45	32	**37**
preferred	15	17	12	19	21	19	21	25	14	**18**
memorable	2	2	0	3	2	1	4	2	1	**2**
total(f+s)	67	59	52	59	67	58	56	67	59	**60**

Table 3. Largemouth bass structural indices from electrofishing surveys at Lake Anna, 1993-2002 (PSD=proportional stock density, RSD=relative stock density; see narrative for explanation).

	1993	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**Mean**
PSD	60	65	60	75	74	75	80	75	65	**70**
RSD-P	29	33	27	36	35	39	43	42	29	**35**
RSD-M	5	4	2	4	3	5	7	4	2	**4**
sites	2	3	6	2	4	3	3	3	3	
N	180	297	441	198	381	290	278	337	294	

Table 4. Catch per unit effort (number of fish per net night) for 25 fish species sampled at Lake Anna with gill nets. Fish listed in decreasing order of abundance for mean catch.

Species	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**Mean**
Gizzard shad	8.5	11.8	9.3	27.1	21.0	6.2	**14.0**
Black crappie	15.0	11.2	13.7	5.5	8.2	12.2	**11.0**
White perch	2.6	8.1	12.5	11.3	15.1	8.5	**9.7**
Channel cat	2.3	5.7	3.5	4.1	5.5	4.7	**4.3**
Striped bass	4.4	3.0	3.1	4.8	3.5	3.7	**3.8**
White catfish	1.9	4.5	3.4	2.2	2.4	1.5	**2.7**
Blueback	1.4	0.7	0.1	8.5	1.0	0.0	**2.0**
Threadfin	1.6	1.0	0.4	3.6	1.6	1.3	**1.6**
Largemouth	1.4	1.2	0.8	1.0	0.7	1.9	**1.2**
Walleye	0.6	0.4	1.0	1.6	1.0	2.6	**1.2**
Spottail shiner	0.6	0.2	0.6	1.0	0.8	0.4	**0.6**
White sucker	0.5	0.8	0.3	1.0	0.7	0.1	**0.6**
Bluegill	0.1	0.2	0.3	0.3	1.1	0.3	**0.4**
Redear	0.2	0.5	0.4	0.2	0.8	0.2	**0.4**
B. bullhead	0.0	0.0	0.1	0.3	0.3	0.3	**0.2**
C. chubsucker	0.1	0.0	0.3	0.0	0.9	0.1	**0.2**
Common carp	0.1	0.1	0.2	0.3	0.3	0.2	**0.2**
Y. bullhead	0.3	0.4	0.1	0.0	0.2	0.2	**0.2**
Chain pickerel	0.1	0.0	0.1	0.1	0.2	0.0	**<0.1**
Quillback	0.0	0.0	0.0	0.3	0.1	0.1	**<0.1**
Yellow perch	0.0	0.1	0.1	0.1	0.1	0.0	**<0.1**
Golden shiner	0.1	0.0	0.0	0.0	0.1	0.1	**<0.1**
Redbreast	0.0	0.1	0.1	0.0	0.1	0.0	**<0.1**
Warmouth	0.0	0.1	0.0	0.1	0.1	0.0	**<0.1**
Blue catfish	0.1	0.1	0.0	0.0	0.0	0.0	**<0.1**

Figure 1 - LMB electrofishing CPUE for fingerling and stock-size fish

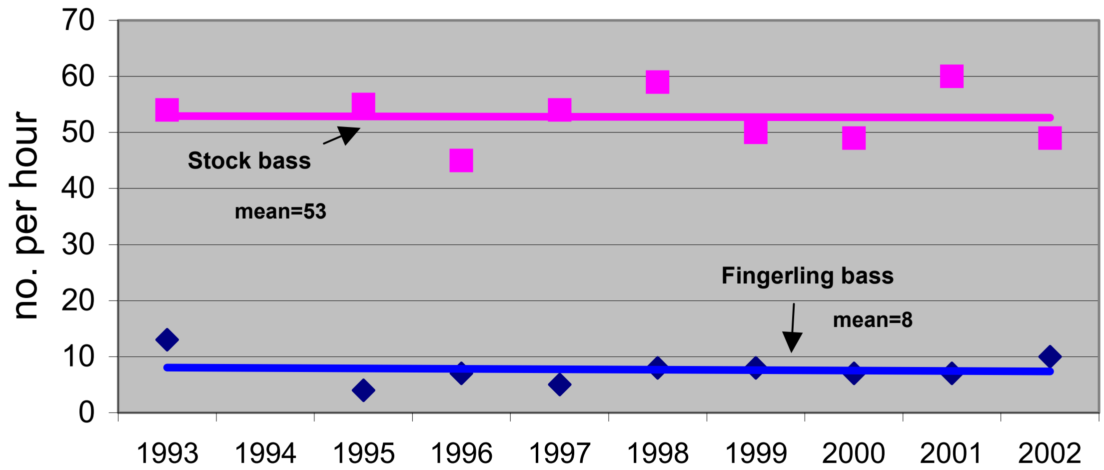

Figure 2 - LMB electrofishing CPUE for quality and preferred fish

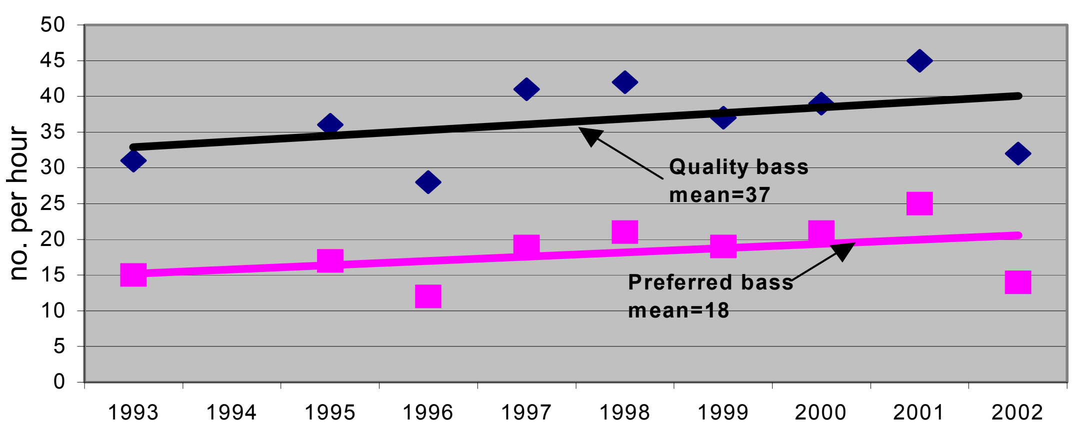

Figure 3. Largemouth bass growth at Lake Anna based on otoliths,mean total length at age.

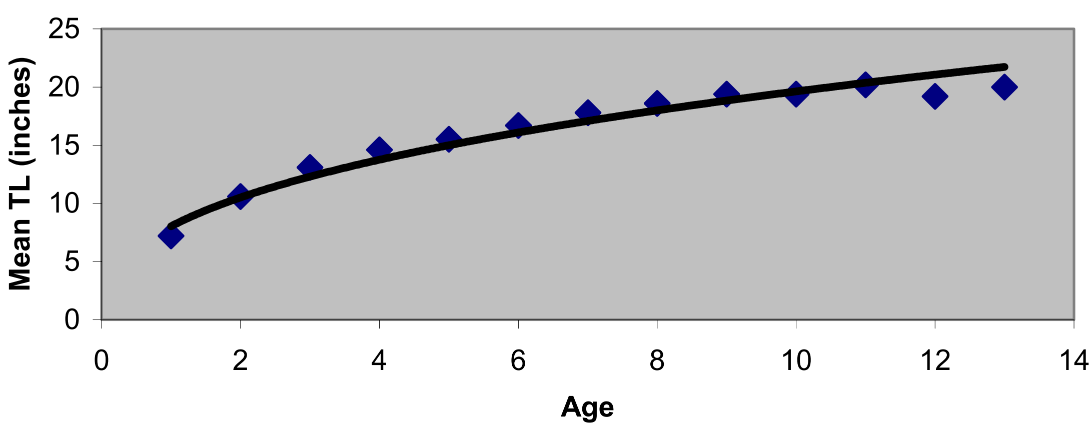

Figure 4. Striped bass growth at Lake Anna based on otoliths, mean total length at age.

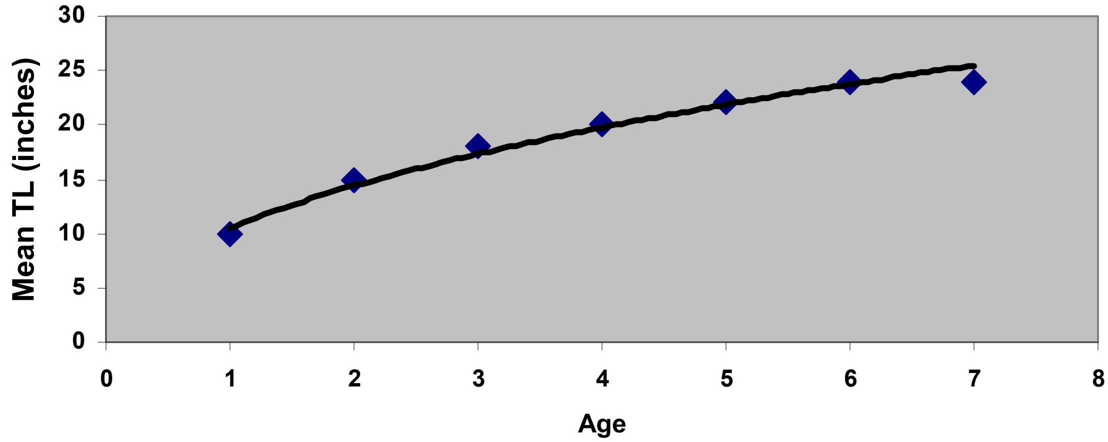

Figure 5. Walleye growth at Lake Anna based on otoliths, mean total lengh at age.

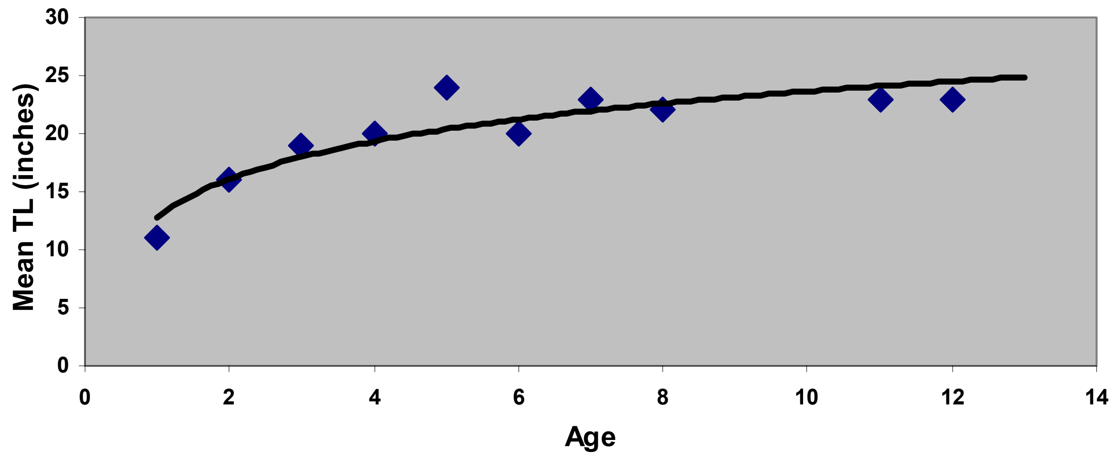

Figure 6. Black crappie growth at Lake Anna based on otoliths, mean total length at age.